U. S. DEPARTMENT OF AGRICULTURE

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PROTECTION OF BUILDINGS *and* FARM PROPERTY FROM LIGHTNING

THE USE OF METAL CONDUCTORS to protect buildings from lightning damage began with Benjamin Franklin's experiment in 1752, since which time the scientific world generally has advocated the protection of houses, barns, and other property from lightning. Experience has proved conclusively that when the equipment is carefully and intelligently selected and installed the protection afforded is almost complete. A number of insurance companies very properly make lower rates for protected buildings, and some companies will not insure an unprotected building.

To protect buildings from lightning, concise, practical, and up-to-date information on the subject is needed; and, to obtain the greatest degree of protection with the type of installation chosen, there should be definite specifications for installing the equipment. This bulletins contains such information.

The three sets of specifications given herein for rods and fittings of different materials will enable the prospective buyer of protection to make an intelligent choice of the one best suited to his needs.

This bulletin is a revision of and supersedes Farmers' Bulletin 842, Modern Methods of Protection Against Lightning.

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PROTECTION OF BUILDINGS AND FARM PROPERTY FROM LIGHTNING

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CONTENTS

DESIRABILITY OF PROTECTION

THE WEATHER BUREAU recommends the protection of all important farm buildings where thunderstorms are frequent and intense, particularly where human or valuable animal life is involved. The best type of equipment should be used when practicable, although almost any kind of an installation is preferable to no protection at all. In the case of a lightning fire, the insurance may nearly reimburse the owner for the money value, but the property is nevertheless destroyed and represents a waste. Moreover, a long period of time may elapse before a building can be replaced, and the contents, as of a barn, may not have been insured, and yet may be the result of a year's labor. Also, many persons experience an exaggerated fear during thunderstorms. A protected building is one of the safest of places at such a time, and the stopping of this fear and the attendant discomfort, apart from the safeguarding of the property itself, fully justifies the installation of an adequate protective system.

It is sometimes stated that lightning conductors "draw lightning," which is true to a slight extent, and that for this reason their use is not desired. A stroke of lightning near a rodded building would very likely be diverted to the conductors and pass to ground without harming the building. On the other hand, if the building were unrodded, the stroke would probably cause damage; hence it is advisable to protect all buildings that are either valuable of themselves or house valuable contents in such regions as are subject to damaging lightning.

The presence on a building of lightning conductors with their elevated points serves in a very small way to discharge electricity

silently during storms. That the silent discharge of a few grounded air terminals on a building or group of buildings can do but little toward preventing lightning strokes can very readily be understood when proper consideration is given to the magnitude of a thunderstorm and the vast accumulation of electricity involved in its relation to the dimensions of houses beneath the storm cloud and the small conductors thereon. The conductors merely serve to direct a stroke to ground should it happen to come near the building. The air terminals and conductors on one building or even on many buildings grouped together are entirely insufficient to prevent strokes, as is obvious from the fact that trees are struck in the midst of forests.

RECORD OF LIGHTNING FIRES IN IOWA, 1919 TO 1924, INCLUSIVE

To show the kind of structures most subject to loss by lightning, also to compare rural and town losses, and those occurring in rodded and unrodded buildings, Table 1 and the accompanying statement are presented.

An analysis of the reported losses from lightning fires in Iowa during the years 1919–1924, as given below, shows that about 72 per cent of the total fire loss caused by lightning in six years occurred among the farm barns and dwellings, of which 60 per cent was due to fires in barns which were unrodded, whereas about 5 per cent took place in barns supposed to be protected by rods. Nearly one-third of these so-called rodded barns, however, are known to have had defective rods. Lightning running in on wires is stated to have caused 10 fires.

The value of rodding is effectively shown. The percentage of total money loss to include all the rodded structures is 6.9, and it is estimated that in the rural districts, where most lightning fires take place, about half of the structures are rodded; so that during these six years, out of each 100 fires 5 or 6 occurred in rodded structures of which a considerable proportion had defective rods. Such fires are preventable.

It is interesting to note that over 17 per cent of the number of fires occurred in town barns and dwellings, but these fires gave only 8 per cent of the money loss. The reason is not far to seek. Fires in rural districts usually result in the more or less complete destruction of the building, whereas fires in town are generally stopped before they gain much headway. The average loss per building in 596 fires in farm barns and dwellings was $2,549, while in town the average was $1,045 for 166 fires among the same kinds of structures. There would be more lightning fires in town were it not for the presence of overhead wires generally protected by lightning arresters and of grounded masses of metal, such as stacks, roofs, structural framework of buildings, etc., which take the place of the usual lightning conductors.

Other unrodded structures which are rather frequently fired by lightning are grain elevators, churches, granaries, and hay, grain, and straw stacks.

Table 1 was arranged from data compiled by J. A. Tracey, the fire marshal of Iowa.

TABLE 1.—*Record of lightning fires in Iowa, 1919–1924*

UNRODDED STRUCTURES

Number	Kind	Loss	Percentage of total loss
514	Farm barns	$1,259,305	60.0
51	Town barns	77,224	3.7
38	Farm dwellings	138,515	6.6
110	Town dwellings	94,431	4.5
18	Churches	43,547	2.1
23	Grain elevators and granaries	138,114	6.6
120	Miscellaneous	202,714	9.6
874		1,953,850	93.1
	RODDED STRUCTURES		
36	Farm barns	$100,631	4.8
8	Farm dwellings	20,730	1.0
5	Town dwellings	1,865	0.1
1	Church	[1] 20,000	1.0
50		143,226	6.9
	TOTAL UNRODDED AND RODDED		
924		$2,097,066	

[1] Rods 28 years old.

Average yearly loss, 1919–1924, inclusive, 154 structures valued at $349,513.

In the January, 1923, publication, "Safeguarding America Against Fire," issued by the National Board of Fire Underwriters, the following statement appears:

Lightning was charged with a total loss of $12,353,222, in 1921 (in the United States), which earned for it sixth place among originating causes. Texas, New York, Ohio, and Pennsylvania, in that order, with losses of $803,276, $709,290, $677,233, and $644,607, led all other States. Notwithstanding the demonstrated efficacy of approved rodding, lightning continues to take toll of the heedless.

The figures quoted are the actual recorded losses, and a fair estimate to include losses not reported would be 25 per cent greater, according to the above-mentioned publication.

METHODS AND MATERIALS USED IN PROTECTION FROM LIGHTNING

KIND OF EQUIPMENT TO CHOOSE

There are several factors that enter into a choice of the type of equipment: (1) The value of the building, (2) the nature and value of its contents, (3) the frequency and intensity of thunderstorms, (4) whether the protection of human or animal life is involved, (5) what sum of money is available for investment in protection, etc. As a rule, especially in regions of frequent and violent thunderstorms, dwellings, barns, and other structures representing a considerable investment, or housing valuable or inflammable material, should be rodded in as effective and durable a manner as possible.

Sometimes the best of materials can not be employed because of limited funds. A less costly installation (for example, the iron-pipe

equipment mentioned below) may then be made at some sacrifice of durability and appearance. Reasonably good protection will be assured until a more durable installation can be made. Moreover, because of their relatively small value, many buildings do not require an expensive equipment, and some buildings little or none at all, depending sometimes upon their relation to more important structures. It is in such situations that the experience of a professional is almost indispensable in making proper decisions as to materials and methods. In connection with the cost of equipment, attention should be called to ornaments such as glass balls, wind vanes, etc., attached to air terminals. They add to the cost but not to the protection against lightning, and sometimes they detract from the stability of the air terminals.

To assist the purchaser of protection in making a choice of equipment to suit his needs, three sets of specifications for typical installations will be found beginning on page 24: (1) Copper-cable conductor and fittings; (2) star-section steel rod and fittings; (3) inexpensive equipment of iron-pipe conductor and fittings.

For general utility in practically all conditions the copper-cable installation is believed to be preferable, with a carefully jointed and heavily galvanized steel rod next. There is usually not much difference between the installation costs of the two kinds. It should be possible to install iron-pipe conductor and fittings for about one-half the cost of the more permanent copper and star-section rods, and good galvanized pipe can be obtained almost anywhere.

MATERIALS USED

The materials or fittings used in protecting a building from lightning may be classified under four heads: (1) Conductors or rods; (2) fasteners for conductors; (3) air terminals, including points if used and elevation rods or tubes and their supports; and (4) ground connections. To avoid electrolytic corrosion the use of two different metals in the same system should, as a rule, be avoided if moisture is continually present. If two dissimilar metals are placed in contact, their drying off quickly after rains or snows is essential to the prevention of corrosion.

Durability should be the principal factor determining the choice of the metal used. Pure copper resists corrosion almost indefinitely while exposed to air free from gases containing nitric acid, or in soil relatively free from ammonia. Thoroughly galvanized steel, carefully selected for its purity, also resists corrosion for long periods both in air and soil exposures, but its use should be avoided in salt-air, humid locations such as are found along the immediate south Atlantic and Gulf coasts, where corrosion of iron takes place with great rapidity, and even well-galvanized iron or steel does not last long. Under such conditions copper-cable installations are preferable, or at least the underground conductors should be copper. Either copper or iron in the forms and dimensions customarily employed possess as a rule sufficient mechanical strength and electrical conductivity, and therefore durability, as previously stated, is the determining factor.

CONDUCTORS

Several kinds of lightning conductors, readily available on the market, are illustrated in Figure 1. For all practical purposes the copper cable and the star-section steel rod are the best forms of con-

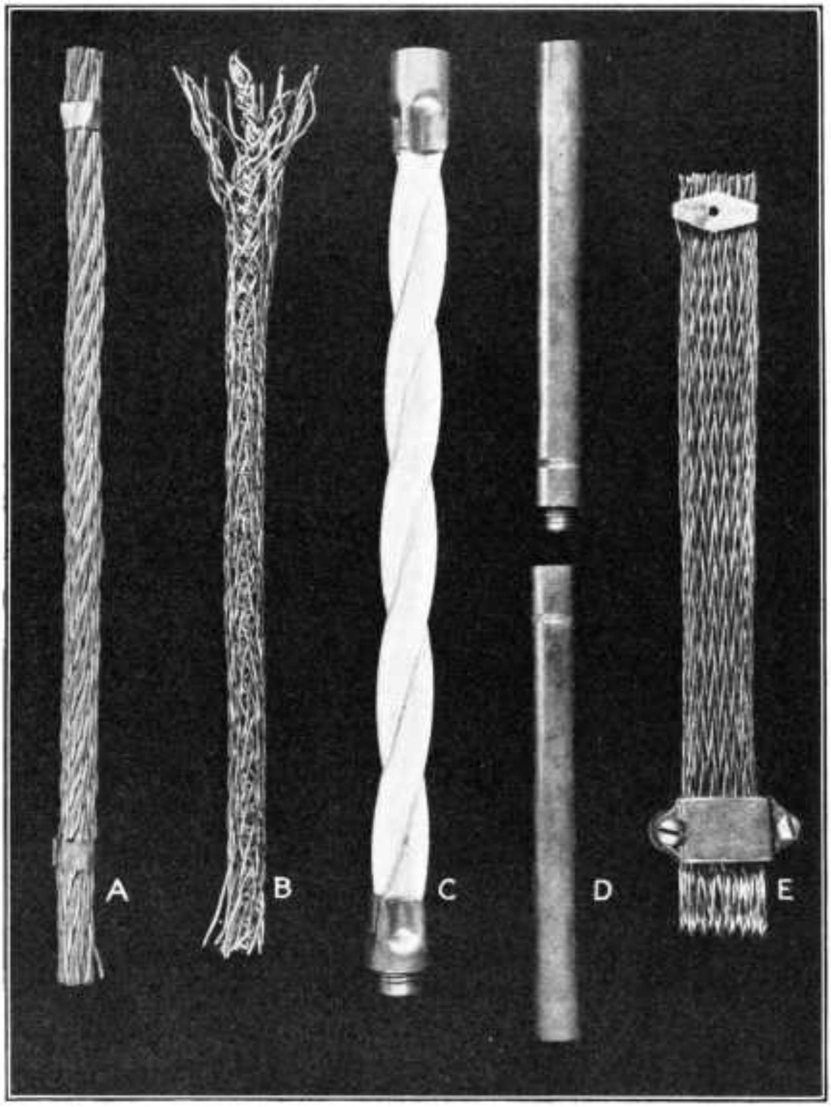

FIG. 1.—Lightning conductors. A, Tight-twisted copper cable one-half inch in diameter; B, loose-weave copper cable; C, star-section steel rod, heavily galvanized; D, copper tube; E, flat copper cable, one-eighth by 1 inch

ductors, although there is no serious objection to the use of a tubular conductor if desired. The cable has the advantage in being flexible and therefore easily installed with few joints, since it may be purchased in lengths as great as 1,000 feet. Sometimes it does not

possess sufficient stiffness because of being too loosely woven. The steel rod, however, once installed makes a mechanically strong, durable job, although the 8 or 10 foot lengths must be screwed together and special tools are required for making bends. Galvanized, or copper-clad steel rods should be used in preference to those formed by wrapping a covering of sheet copper about the rod. This latter construction is objectionable because of the possibility of galvanic corrosion of the iron should water find its way through the seam of the copper cover, which corrosion may obviously occur without it being observed, since the external appearance of the rod remains unchanged. In the better forms of these rods the copper is lock-seamed, but there is still the danger or the uncertainty that the seam may be opened when the rod is bent. However, the copper-clad steel conductor which has a coating of copper welded to the steel, is satisfactory.

Painting conductors above ground does not detract from the value of the conductor, and the life of steel rods may be increased by painting them as soon as serious corrosion is in evidence. But when freshly galvanized iron or steel is painted without previous preparation, the paint tends to peel or crack, and in addition the protective coating of zinc is liable to injury. Conductors forming the earth connection should not be painted, since the electrical resistance of the "ground" is thereby much increased, whereas the resistance should be as low as practicable.

FASTENERS FOR CONDUCTORS

A variety of fasteners for securing the conductor to various portions of a building is shown in Figure 2. The kind chosen for a particular installation depends largely upon the construction of the roof and walls of the building, the kind of installation, and upon whether the fasteners are to be put in place while the building is being erected or attached after it is finished. Strap fasteners (fig. 2 D) held by galvanized or copper-plated nails and less often by screws, are extensively employed with considerable satisfaction for attaching conductors to wooden surfaces, judging from the condition of the fastening after long periods of time. However, for general all-around usefulness for round-section conductors, the screw fastener (fig. 2, C) appears to be excellent, since it is adapted to any kind of surface. Figure 3 illustrates their attachment to a roof. They are screwed directly into the wood, or used with expansion sockets in masonary walls. These fasteners are not easily loosened after being screwed into place; they are strong and not subject to corrosion. The cable is easily inserted in the open loop and held securely by squeezing the two prongs of the fastener together with pliers. The other types of fasteners shown are all more or less seviceable. Their use is mentioned in the legend.

AIR TERMINALS

Air terminals are the parts of a lightning-conducting system which provide an elevated object to receive the discharge, thus preventing damage to the building itself. Sharp points discharge silently to an undetermined but probably slight extent, but such an authority

as Sir Oliver Lodge, in the publication, Lightning Conductors and Lightning Guards, states that "the amount of electricity they can get rid of * * * is surprisingly trivial, and of no moment whatever when dealing with a thundercloud." The upper end of an ele-

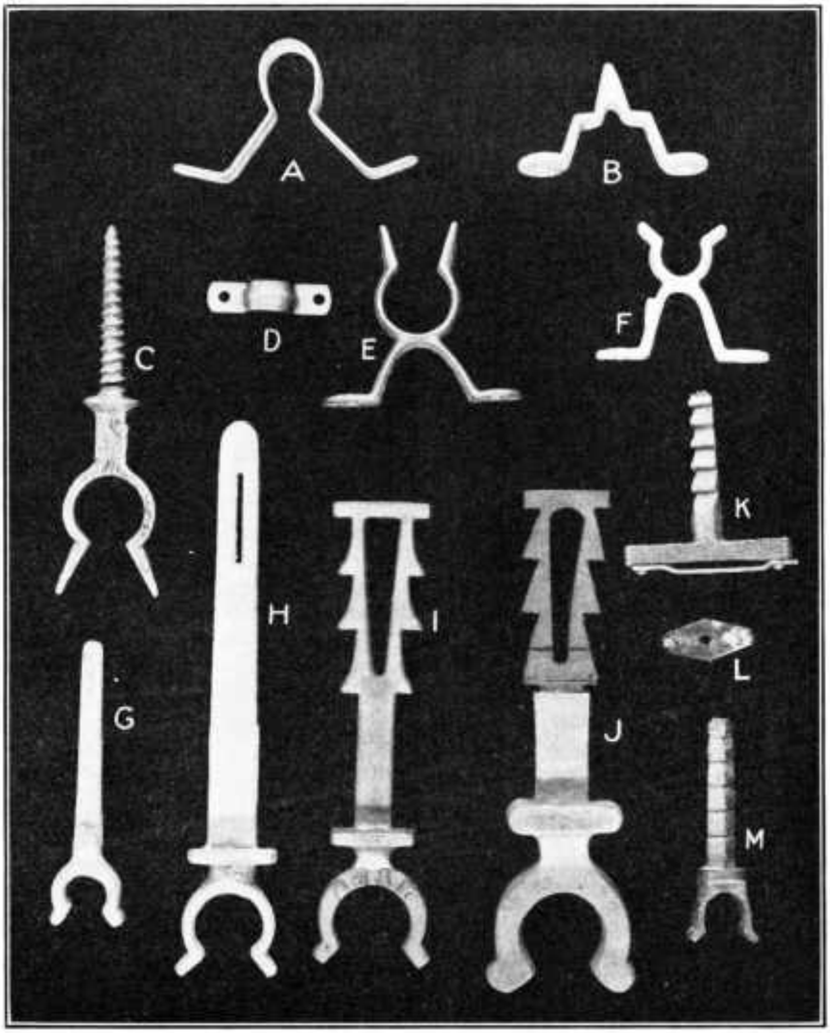

FIG. 2.—Conductor fasteners: A, Loop fastener for cable, also used for star-section rod; B, for star-section steel rod laid flat on surface of building; C, screw fastener for cable, also used for star-section rod; D, clip for cable laid flat on surface; E and F, "disperser" attachments for rod and cable; G, H, I, J, K, and N, various forms of fasteners used with cable and star-section rod adapted to masonry or concrete. J is a chimney fastener coated with lead to protect from corrosion. K is used with flat copper cable, as is also L, the latter being secured with copper nails. (See fig. 1, E.) A, B, D, E, and F are usually secured to the surface with galvanized nails, but screws would make a better job

vation rod may be blunt and still serve the purpose without being subject to fusing when struck by lightning.

Complete air terminals, as customarily made, are illustrated in Figures 4, 5, and 8. They usually consist of three parts: (1) The

point, (2) the elevation rod or vertical conductor, to the upper end of which the point is attached, and (3) the tripod support. When the elevation is short, as shown in Figure 6, F, its erect position is maintained through its firm attachment to the horizontal conductor on the roof; but, for heights of 14 inches to 5 feet, galvanized-iron tripod supports are employed for the ordinary air terminal, which supports are often attached to the roof by galvanized nails. Screws would be better, and where ready access may be had to the underside of the roof a very secure attachment can be obtained by the use of bolts, as shown in Figure 7. Air terminals erected as described and illustrated are seldom damaged by wind or by the snow and ice storms of winter.

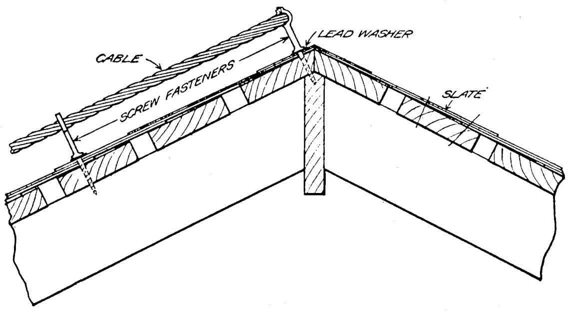

FIG. 3.—Use of screw fasteners on shingle, metal, or slate roofs. (See fig. 2, C)

Several kinds of points for air terminals are pictured in Figure 6. The copper tube or so-called shell point is extensively used with the copper-tube elevation rod, and when the point proper is made solid for 3 inches or so from the end, and the walls are not less than No. 20 (0.032 inch) gauge in thickness, they are sufficiently heavy to withstand the fusing effect of severe strokes. It is sometimes replaced by the copper bayonet point, a solid, substantial fitting which in general is preferable. The bayonet point is also used with star-section steel elevation rods. Multiple points (fig. 6, A and B) may be used without objection when the individual points are sufficiently heavy, but one large-sized heavy point is enough for one air terminal and the expense is less. The plating of the points does not add to their usefulness unless it prevents corrosion. Where conditions causing corrosion are severe, points are plated with lead; otherwise nickel or chromium plating is insufficient.

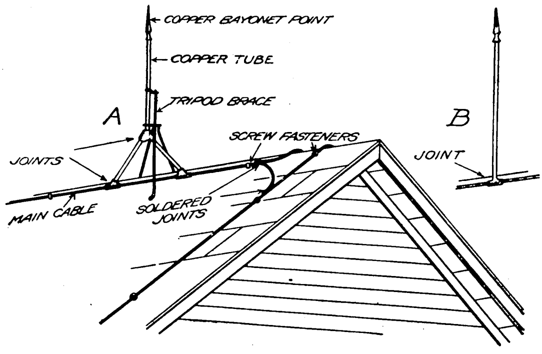

FIG. 4.—Copper-tube air terminal with iron tripod support. A, inverted Y connection of elevation rod to main conductor; B, customary T connection to main conductor

The attachment of the elevation rod to the main conductor may be satisfactorily accomplished in several ways, as indicated in the illustrations. Tube elevation rods have their lower ends formed into such shape as to encircle a copper cable and be squeezed firmly

into contact with it, no solder being used. Star-section rods are provided with screw fittings, but both kinds are usually so installed as to make a right angle with the main conductor. A little additional cost would provide a **Y** connection, as shown in Figures 4 and 5, and thus avoid the arcing of the discharge across the right angle, which is possible with the customary connection

METHODS OF INSTALLING EQUIPMENT

When one has decided to protect his property against lightning, the next questions to answer are: What type of equipment is best under the conditions? How shall the work be done? Generally it will be necessary to call upon an expert to plan and install the equipment and to furnish the materials needed, but the methods to be employed should be common knowledge to both parties to the contract. If the installation is to be an extensive one it would be advisable to submit brief specifications to several competitive bidders, giving a general outline of the materials and methods to be employed. The work should be carefully followed during its progress, particular attention being given to the manner in which the grounds are made. A reputable contractor, however, will guarantee his work, and such a contractor should be given preference. Morover, he will often follow up his work with periodic inspections in order that any defects may be repaired. The owner should not depend entirely upon such service, but should also watch the equipment and prevent its deterioration. Thoroughly reliable protection can not otherwise be maintained. As with many

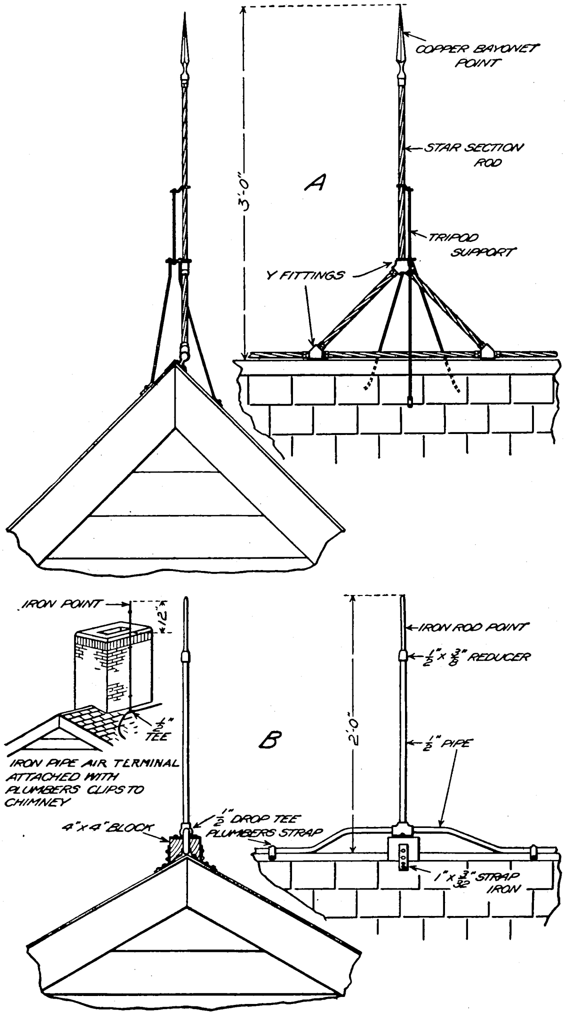

Fig. 5.—Air terminals formed of, A, star-section steel rod; B, one-half inch galvanized iron pipe and fittings

other kinds of construction, first-class materials, good workmanship, coupled with care of the equipment after purchase, give the lowest cost and the best results in the long run.

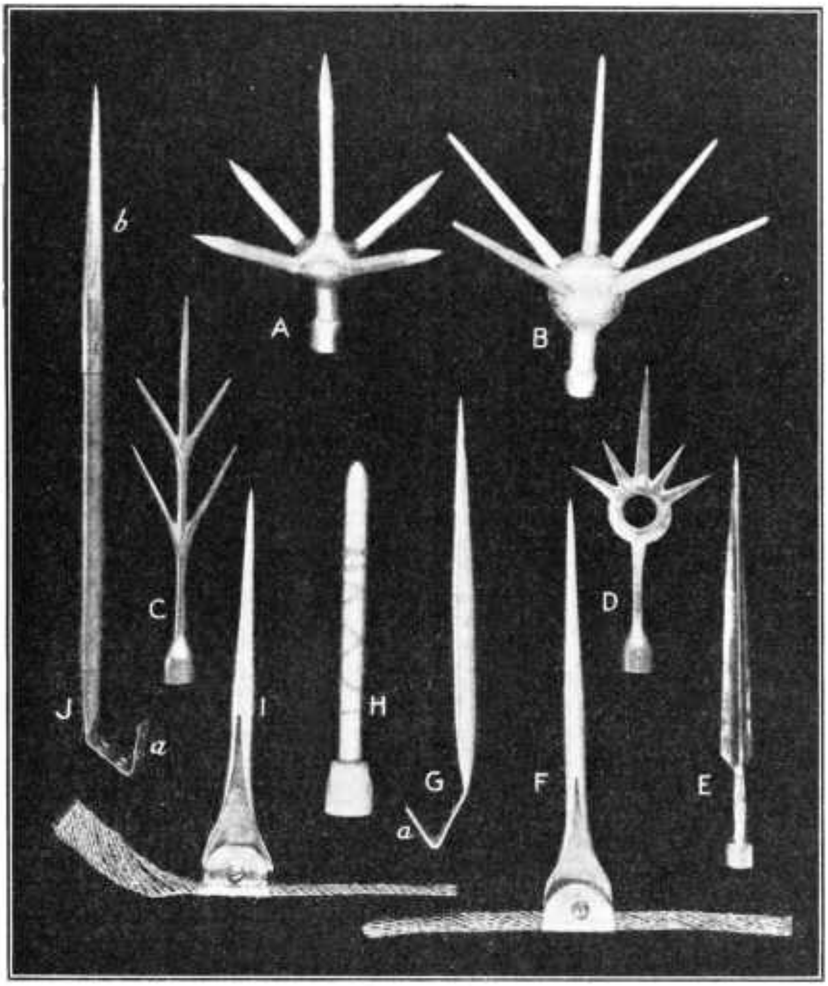

FIG. 6.—Air terminals and points. A, B, C, and D are multiple points used with tubular or star-section elevation rods. E, solid copper-bayonet point for attachment to tubular or star-section elevation rods. F and I, short air terminals of tubing, the lower end of tube opened up and fastened to round or flat cables. G and J, short air terminals for attachment to flat cables, part *a* being bent around the cable and both fastened to roof by nails or screws. H, point for iron pipe air terminal. (See fig. 5, B.) Part b of air terminal J, called a shell point, is very frequently used with tubular air terminals of all heights. (See figs. 4 and 8 and fig. 9, F.)

The methods to be followed in installing the various portions of the equipment are given in detail below.

CONDUCTORS

Conductors of whatever kind should be coursed over the building so far as possible in straight runs to form an approximately inclos-

ing network, avoiding unnecessary and sharp bends, the changes in direction being made if practicable in curves of ample radiuses, so as to avoid arcing of the electric current across angles because of abrupt changes in the direction of the conductor. Figure 8 illustrates the manner of coursing conductors around chimneys and over the edge of a roof. As a general rule conductors shall everywhere preserve a downward or approximately horizontal course.

Where end-to-end joints of the conductors are necessary, suitable solderless connectors may be employed; or when copper cable is used the joints wrapped and preferably soldered. The various methods are illustrated and described in Figures 9 and 10. Joints are almost entirely avoided in copper-cable installations, since the cable may often be run over a building from one corner to that diagonally opposite without a break. Branches from a main conductor of copper cable may also be soldered, or fittings used which preferably avoid right-angled connections.

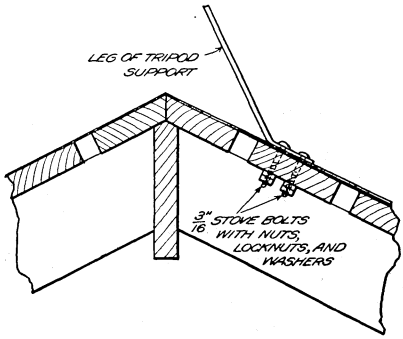

FIG. 7.—A method of attaching leg of air terminal support to roof, where access can be had to underside of roof. Iron tripods are, however, usually nailed or screwed down

SPACING AND ATTACHMENT OF CONDUCTOR FASTENERS

Fasteners for securing the conductors to the walls and roof of a building should be spaced not more than 4 feet apart as a rule, depending somewhat upon the kind of conductor, and modified, of course, by the construction of the building. The principal aim is to obtain a neat and durable job, with the conductor firmly held in place.

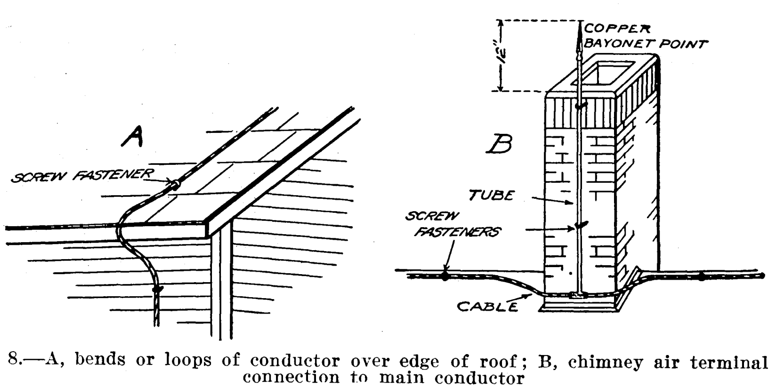

FIG. 8.—A, bends or loops of conductor over edge of roof; B, chimney air terminal and connection to main conductor

Holes through the roof made by the fastener screws or nails should be made water-tight.

INSULATORS NOT REQUIRED

Insulators, so called, made of porcelain, are sometimes combined with a fastener, the conductor being threaded through a hole in the

insulator. The advantage claimed for insulators is that in the event of a heavy discharge the rise of temperature of the conductor, owing to the passage of the electric current, might cause the ignition of dry

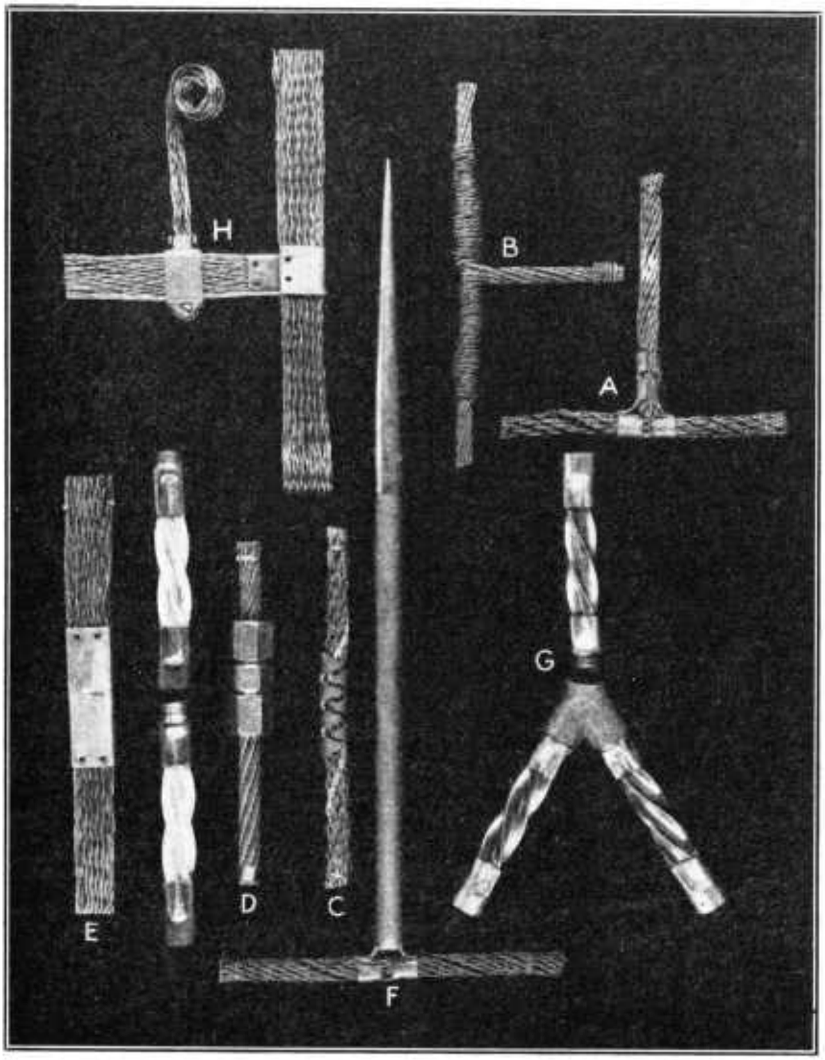

FIG. 9.—Conductor joints and air-terminal connections to main conductor. A, right-angled joint of copper cable, using a copper fitting. B, joint of copper cable made by wrapping strands of one cable about the other; the joint should preferably be soldered. C, D, and E, end-to-end joints of copper cable. C is a copper fitting wrapped about the cable. D, a solderless conneetor. E, a flattened copper tube with the eable ends inserted therein and all held together by nails driven through holes in tube to surface to which conductor is attached. F, right-angled joint of tubular air terminal to main conductor of copper cable. G and H, Y branch and end-to-end joints of star-section steel rod. I, right-angled joint of flat copper cable. Fitting for attachment of eable used for cross connection also shown

wood or some inflammable material were the conductor fastened direct to the surface; the conductor is therefore separated from the wall and insulated. There is no evidence, however, that the rise of

temperature in a conductor of proper weight per foot will at all endanger the building. In fact, a good electrical connection of the conductor with the wet roof and walls of a building helps to relieve it of its charge. Insulators appear to be unnecessary and add to the expense and somewhat to the insecurity of the attachment of the conductor.

AIR TERMINALS

The locations of air terminals should be carefully chosen, having in mind their placement on elevated and upward-projecting portions of the building, such as chimneys, peaks, towers, gable roofs, ventilators, ridges, and dormers. Twenty-five feet is the maximum spacing along the edges of flat roofs and the ridges of hip roofs. On extensive flat roofs it is therefore necessary not only to erect air terminals along the edge of the roof to form an inclosing loop but at points within, the distance of the inside terminal being not greater than 50 feet from those adjacent, all connected by a network of conductors.

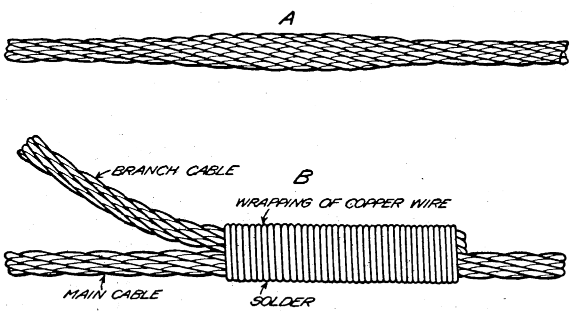

FIG. 10.—Other methods of forming conductor joints. A, end-to-end joints of copper cable. B, side branches

Sketch plans and elevations of the building to be protected, with the air terminals, conductors, and grounds shown thereon, are usually necessary, and especially so when specifications are submitted to bidders. Figures 22 to 25, inclusive, are examples of typical installations to serve as guides to the prospective purchaser of equipment.

AIR TERMINALS FOR STEEPLES AND TOWERS ON BUILDINGS

Such salient structures as steeples and towers require one or more air terminals, depending upon their construction, and two down conductors, one going directly to a separate ground, while the other may be connected to one of the grounds of the main system of conductors. See Figure 25 for the rodding of a church. Metallic masses in steeples and towers should be cross connected to the rods as outlined on page 19.

HEIGHT OF AIR TERMINALS

The air terminal should extend to a height of not more than 60 inches nor less than 10 inches above ridges, gables, or flat roofs. A height of 10 to 14 inches above the top of an ordinary chimney is sufficient, as a rule, and short air terminals are all that are required on pointed portions of a building, such as peaks and steeples. In general, the height of air terminals is dependent on the configuration of the roof and the material of which it is made.

GROUND CONNECTIONS

The electrical connection of the lightning conductors on a building to permanently moist, and therefore conducting earth, or what

is usually termed "grounding," is the most important part of the protective system, for unless the grounds are properly made the efficiency of the system is much reduced. Hence, every precaution and care should be taken in constructing the grounds to the end that the electrical resistance may be as permanently low as practicable. To obtain the best results, several essentials are necessary: (1) The soil in which the metal forming the ground is placed must, if possible, be permanently moist; (2) the area of contact between the metal and the soil must be ample—better in excess than not enough, since it is not the custom, however desirable, to measure the electrical resistance of grounds; (3) the metal in the soil must be electrically connected to the down conductor in as permanent a manner as possible; and (4) the corrosion of the metal used in the earth must be as slight as practicable.

To fulfill the first condition, the moisture content and character of the soil in which the ground is to be made should be carefully determined before the kind of ground connection is selected, allowance being made for the dryness or wetness of the season at the time of the inspection, for good and reliable grounding generally requires electrical connection with that level at which the soil does not dry out during droughts, when the electrical conductivity of the soil is much reduced. Occasionally it will be impracticable to reach permanently moist earth because of the rocky nature of the soil. It is then necessary to resort to the more expensive alternative of largely increasing the area of the ground connection by extending it horizontally and radially from the building as far beneath the surface as is practicable or economical. Occasionally a difficulty of this kind is met by burying a copper conductor in a trench extending entirely around the building and joining this ground connection to the two or more down conductors on the building. Another alternative is to increase the number of grounds of the usual type.

The distribution of the grounds is also an important factor. In general, they should be as far apart as practicable, not less than two in number, and spaced more or less equally from each other; but when it is necessary to make a connection to a water pipe or to avoid soil or chemical substances that will corrode the ground connection, it is obvious that the ground must be placed wherever convenient. Furthermore, the moisture conditions of the soil may not be the same at different places about the building, and of course the moistest locations should be given preference.

There must be two paths for a lightning discharge from every air terminal to ground, and "additional down conductors shall be installed where necessary to avoid dead ends exceeding 16 feet in length"; that is, if an air terminal is set more than 16 feet in a horizontal direction from a roof conductor, it must be connected, not only to the roof conductor but also to ground by means of one or more additional conductors. Ground connections should extend below the foundation walls of a building to avoid damage to the walls.

Durable ground connections can be realized only by giving preference to such metals as will not readily corrode in the soil where placed. Copper, bronze, and cast iron in their commercial purity generally fulfill this condition, and heavily galvanized or copper-

clad steel are also satisfactory. Of the three first mentioned, copper is the most readily available and cheaper than bronze; cast iron is seldom used, since the customary forms, such as pipe, are rather unwieldy to handle and therefore more costly to install. In practice copper and galvanized steel have the field practically to themselves. Common salt is sometimes placed about the upper end of the ground connection to decrease its resistance, but this advantage is temporary, however, lasting only until the salt is dissolved and carried away, when it must be replaced.

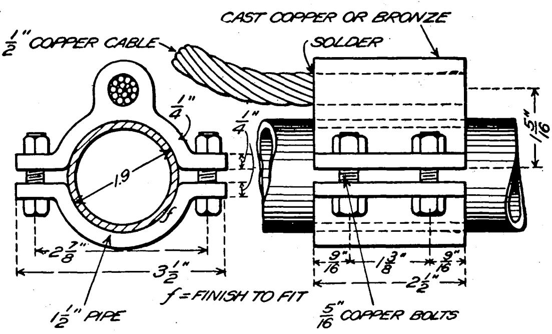

FIG. 11.—Clamp for water-pipe ground connection

DETAILS OF CONSTRUCTION OF GROUNDS

Grounds may be constructed in accordance with any of the methods described and illustrated below. Connections to water piping where it enters the building constitute generally the best ground available. Such connections should be well made, and Figure 11 shows one method.

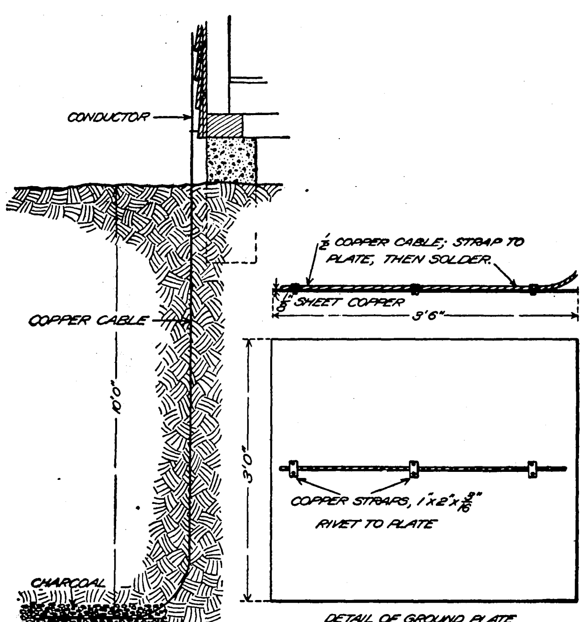

FIG. 12.—Copper-plate ground connection

COPPER PLATE GROUNDS

Figure 12 shows a copper plate having an area of about 10 square feet to which the copper down conductor is securely riveted and soldered. The thickness of the plate is one-eighth inch. Somewhat thinner metal might be used, but for long service the thickness mentioned is none too great. A ground plate of this character should be buried in earth where there is permanent moisture, with 4 or 5 inches of pea-size broken charcoal above the plate and about the same thickness below, which mainly has the effect of increasing the area of contact of the ground connection

with the earth and thus lowering the electrical resistance. The charcoal also absorbs water and therefore assists somewhat in maintaining a moist condition about the plate.

GROUND CONNECTIONS FORMED BY EXTENSION OF DOWN CONDUCTOR

In deep soils of moist loam over clay, or other soils similar in character, very satisfactory grounds are customarily constructed at a small cost, when compared with plate and stranded-cable grounds, by first drilling vertically into the soil to a depth of 8 to 10 feet and then carefully inserting or, where possible, driving the conductor into the hole. The drill used is shown in Figure 13. A hole about 1 foot square and 1 foot deep is first dug in the surface of the earth and filled with water, and the drilling started about the center of the bottom and continued until the proper depth is reached, the drill being removed, if necessary, at intervals to dispose of the surplus soil. The loose soil mixed with water fills in around the conductor so that there is eventually good electrical connection between conductor and earth.

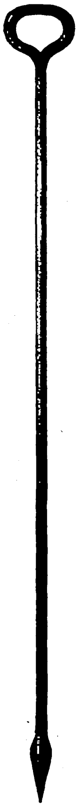

FIG. 13. — Earth drill for making ground connections by extension of down conductor

There is danger sometimes that a cable conductor will be pulled out of the earth. This result should be avoided by recourse to some such method as is illustrated in Figure 14.

Where the soil is rocky or gravelly and the above-described grounding is not practicable, some other method must be employed, but under no circumstances should an attempt be made to ground the down conductor by merely inserting a short length of its lower end in the earth. The area of contact of the metal with the soil is entirely insufficient to provide a ground of the necessary low resistance, and it is almost certain that the top layers of the soil will dry out at intervals, thus increasing its electrical resistance greatly.

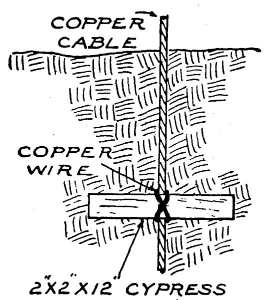

FIG. 14.—Block of wood wired to cable conductor to prevent its being pulled out of the earth

STRANDED-CABLE GROUNDS

Where the soil does not permit of drilling vertically to a sufficient depth, a satisfactory ground may be constructed, using copper cable, by burying the conductor in a narrow trench extending away from the foot of the down conductor for a distance varying with the depth, for with a rocky soil the trench must be more or less shallow. For a depth of 5 feet a length of 15 feet would be a fair estimate; decreasing the depth to 4 feet would require, say, 20 feet of length, and other depths are estimated in a similar manner. Having dug

the trench, separate the strands of the cable along the bottom, the cable entering the trench in a long bend, about as shown in figure 15. The conductivity of the ground connection thus formed may be increased somewhat by embedding the stranded cable in pea-size charcoal, saturating with water, and tamping the earth thoroughly as the trench is filled. The resistance may be still further lowered by splicing a second length of cable to the main conductor near the bottom of the trench at the house end, and running both of the stranded cables to the end of the trench or in separate trenches if desirable.

PIPE-GROUNDS

Ordinarily galvanized-iron pipe may also be utilized for grounds, but the life of such pipe embedded in the soil is relatively short as compared with copper; a pure wrought-iron pipe would be more durable. Pipe grounds, therefore, should preferably be used for temporary or moderate-priced installations, unless their condition can be determined periodically and replacements made when necessary. If galvanized pipe is used for a conductor, the arrangement shown in Figure 16 should be employed, the ground connection being $1\frac{1}{4}$-inch pipe. Special fittings are available for driving pipes into the earth.

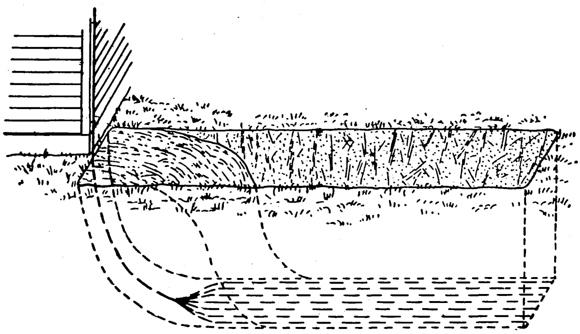

FIG. 15.—Stranded-cable ground connection

It is also possible to use a length of cast-iron pipe for a ground as shown in Figure 17. The pipe should preferably be placed under a down spout so that rain water can flow downward alongside the walls of the pipe and keep the soil wet.

COPPER-CLAD STEEL RODS

Copper-clad steel rods in suitable lengths and sizes for ground connections are being increasingly employed.

INTERCONNECTION AND GROUNDING OF THE METAL WORK OF BUILDINGS

EXTERIOR METAL WORK

All the exterior metal parts of a building of any considerable extent and size, such as roofs, gutters, down spouts, finials, soil or vent pipes, and other metal masses projecting through the roof or the sides of the building above the second floor should be carefully cross connected to the lightning-rod system, unless the manner of installing the air terminals or conductors has already placed the metal work in good electrical contact with the lightning conductors.

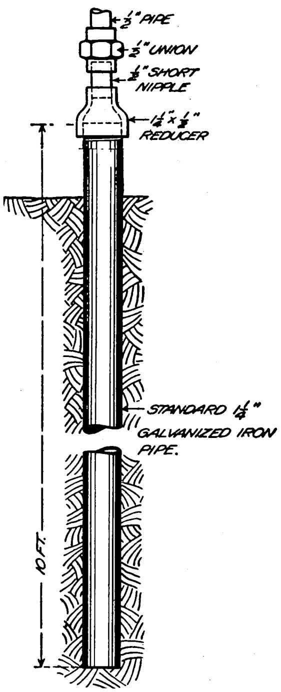

FIG. 16. — Galvanized-iron pipe ground connection

Usually it will be necessary to make permanent and dependable connections with copper wire or cable, soldering or thoroughly clamping the joints. No. 6 B. & S. gauge wire, or its equivalent in a cable, is a satisfactory size for this work. Metal bodies of considerable size or extent should be connected at top and bottom or from the ends to the nearest lightning conductors. Often the conductors are run alongside such metals, and cross connections can be very easily made. In the case of down spouts, if the gutters are cross connected to the conductors and the joints of gutters to down spouts soldered, no cross connection of the latter to the conductors will be necessary at the upper ends. The lower ends must be grounded, either directly or by connection to near-by down conductors. The conductors used to make the cross connections should be securely attached to the building in a neat and durable manner without being too conspicuous, and a strap fastener similar to the one illustrated in Figure 2, D, made of the same material as the wire, may be used for the purpose. A staple would also make a good fastener where the wire runs over the wooden surface of a building. Where necessary the cross connections should be protected from mechanical injury.

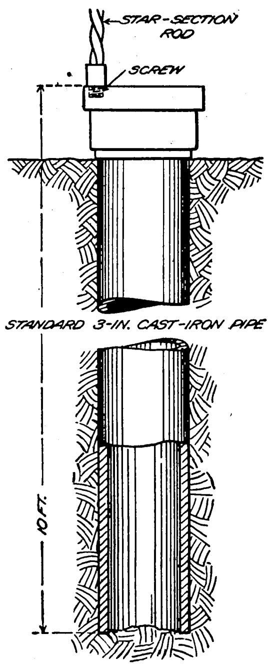

FIG. 17—Cast-iron pipe ground connection

METAL-COVERED STRUCTURES

Ungrounded metal roofs do not give protection from lightning, and at times they increase the probability of damage by fire, for an induced charge in the roof, caused by near-by lightning, may find its way to earth within the building, igniting inflammable materials in its path.

Metal-roofed and metal-clad buildings, however, when properly grounded in accordance with the procedure given above, usually require but little further attention to make them reasonably safe from damage by lightning. The following quotation, taken from the Code for Protection Against Lightning,[1] by the American Standards Association, states the practice with especial clearness:

Paragraph 214: METAL-ROOFED AND METAL-CLAD BUILDINGS.

(*a*) *Metal in overlapping sections.*—Buildings which are roofed or roofed and clad with metal in the

[1] Miscellaneous Publication No. 92 of the Bureau of Standards may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 25 cents.

form of sections insulated from one another, or so applied that they are not in metallic contact, shall be treated in the same manner as are buildings composed of nonconducting materials.

(*b*) *Metal continuous.*—When buildings are roofed or roofed and clad with all-metal sheets made electrically continuous by means of an interlocking or other contact, or by bonding, the following modifications may be made:

Air terminals need be provided only on chimneys, ventilators, gables, and other projections, such as are likely to receive and be damaged by a stroke of lightning. Projections that are likely to receive, but not be damaged by, a stroke of lightning need not be provided with air terminals but shall be securely bonded to the roof.

Roof conductors may be dispensed with and elevation rods, if used, connected to the roof by soldered joints, or securely bolted joints, having an area of contact of not less than 3 square inches (19.3 cm.^{2}). If the roof metal is in small sections, connection shall be made to at least four of the sections.

Down conductors shall be connected to the edges of roofs, or to the lower edges of metal siding, by soldered or bolted joints having an area of contact of at least 3 square inches (19.3 cm.^{2}). If the metal is in small sections, connection shall be made to at least four of the sections.

Interconnection of interior metal work in a metal-covered building should be carefully done, especially in barns housing inflammables, using the metal cover in place of the usual lightning conductor to which to make connections, when the cover is continuously conducting and well grounded.

INTERIOR METAL WORK

Pipes of all kinds, and other metal bodies extending for a considerable length parallel to the lightning conductors, should be connected to a conductor at one end and grounded at the other within the building or connected to another conductor on the exterior; provided the distance from the conductor to the interior metal work is less than about 6 feet, or more if the mass or extent of metal is great. When the distance exceeds 6 feet, grounding alone is necessary. The methods used in making such cross connections are similar to those described for exterior metal work. Grounds within a building can frequently be made to water piping, using a form of clamp similar to that illustrated in Figure 11. Moderately small masses of metal may be grounded only, but the extent to which cross connections should be carried is governed by the nature of the contents of the building and its construction; farm barns, for example, containing unbaled hay, or other easily ignited materials, should be so cross connected as to make induced discharges from the metal work to ground through these materials impossible.

GROUNDING OF WINDMILL AND OTHER STEEL TOWERS

Towers used to support windmills ordinarily do not require any special protection against lightning, since they are constructed of steel and well grounded through the pump. Wooden water tanks placed upon steel towers should, however, be surmounted by an air terminal connected to the metal work of the tower, and the latter well grounded by one of the methods already described, should the anchor posts of the tower be embedded in concrete. When the posts are merely placed in the earth the grounding is usually sufficient, depending upon the character of the soil and the height of the water table. The same treatment should be given flag, signal, and bell towers built of steel.

OVERHEAD WIRES

Overhead wires entering a building for electric light and power, radio, or telephone circuits occasionally provide a path by means of which lightning also finds access to the building with resulting damage. Well-installed lightning arresters placed as near as possible to the point of entrance of the wires to the building provide a reasonably effective safeguard to the building and the connected instruments. The ground connection for the wires should be well made and separate from the lightning-rod grounds. It is customary practice to thus protect telephone circuits, and radio receivers joined to outside aerials require similar treatment. Installations should be made according to the "Rules for protecting telephone and radio circuits from lightning," as given in the National Electric Code (pp. 30 to 32, inclusive).

A good general rule with respect to any incoming wire is to keep it 6 feet or more away from grounded lightning conductors; arresters for such wires should be grounded separately.

The development of farm-lighting plants and the radio have introduced new conditions from the standpoint of protection from lightning. Adding either electric-lighting or radio-receiving sets to the farm home increases the risk of damage from lightning unless they are properly cared for. Overhead wires are run from one building to another to carry the electric light circuit, and at their point of entrance to a building it is necessary to install lightning arresters and ground them; also to cross connect or ground the conduit, when it is used in the building, according to the methods previously given for interior metal work.

Electric light and power lines from a distant central station are protected from lightning by the company furnishing the service. The degree of protection provided varies according to what the company deems to be sufficient, depending in part upon the frequency and intensity of thunderstorms. Though it is not customary to place lightning arresters at the point of entrance of the service wires to the building, when the grounded transformer is located at a considerable distance from the building and the secondary low-potential circuit to the building is perhaps 200 feet or more in length, an additional measure of safety to the buildling and line will be obtained by installing arresters at the building end. The question of protection should be taken up with the electric service company having in view as before stated the length of the secondary circuit and the degree of severity of the electrical storms in the vicinity, as evidenced by the frequency of occurrence of fires started by lightning running in on wires.

With regard to outdoor receiving aerials for radio and their lead-in wires, as mentioned above, the rules covering the installation of the grounding switch and lightning arrester are given in the appendix. An outside aerial strung from an elevated portion of the house to a distant support may obviously be struck at any point of its length, in which event the current would ground more or less through the switch or the arrester. But the usual No. 14 gauge aerial and lead-in wire, with the switch and ground connections, are insufficient to carry a heavy lightning current; the wire would most likely be melted or volatilized sideflashes occurring to what-

ever grounded conductors are nearest the path of discharge. The need for a thorough protection of buildings under these conditions, particularly of farm buildings where the lightning hazard is greatest, should be apparent. If a pole of considerable height is used to anchor the house end of the aerial, it would be advisable to place an air terminal on it and connect to the nearest lightning conductor; if a metal pole is used, it should be grounded.

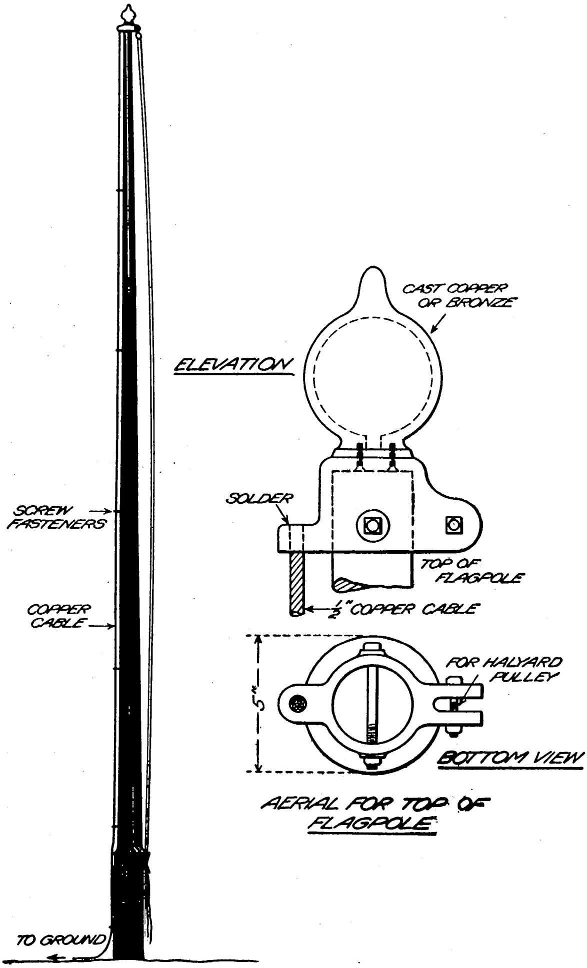

FIG. 18.—Protection of wooden flagpole

RODDING SILOS

Inspections of lightning-rod installations have frequently shown that, in addition to the failure to provide for the protection of rodded buildings when the above-described wiring is added, silos have been built without attention to their relation to the lightning rods already in place. These structures are usually close to the barn and should be tied into its rodding. Good practice generally requires

a separate ground, and also a second connection from the single air terminal on the silo to the lightning rods on the barn. (Fig. 24.)

PROTECTION OF FLAGPOLES

Wooden flagpoles are very frequently struck by lightning and considerably injured or rendered useless. A flagpole, however, can be almost completely protected from such damage by surmounting the pole with a metal fitting to form an air terminal, essentially as shown in Figure 18. The use of a special bell-shaped casting, preferably made of bronze, to fit the top of the pole, is recommended, the point of which is sufficiently blunt to prevent the flag from catching should it be carried upward with the air currents. The down conductor should be attached to the pole with suitable fasteners, carefully soldered to the casting at the top of the pole, and connected to a separate ground when the pole stands by itself in the open or joined to the lightning-rod system on the building when erected on the roof. Metal flagpoles should be grounded.

PROTECTION OF TREES

If a building is more or less surrounded by high trees, these trees protect the building from lightning to a great extent. This is especially true of deep-rooted trees which are more liable to lightning damage than other. Poplars, oaks, pines, elms, ash, etc., are of this kind. But the trees should be considered only as an additional protection to the building, and the customary equipment should be provided for the latter. Large, full-grown trees near a dwelling are valuable as a rule, and if it is desired to protect them from lightning, a few of the larger ones should be rodded, as follows: Place an air terminal in the top of the tree, but not so high as to be insecure, and ground it through one or two down conductors, the number depending upon the size of the tree. Screw fasteners with a long shank are desirable for holding the down conductors in place along the tree trunk in preference to a rigid fastening. One of the grounds provided for the conductors on the building may be used if convenient, or separate ones constructed at the foot of the trees. In order that a lightning discharge shall not damage the root system of the tree protected, it is generally advisable to construct shallow grounds, essentially as described under "stranded-cable grounds." It is realized that the growth of the trees will make it difficult at times to maintain the rodding, and its extension, partial renewal, or repair will occasionally be needed, especially on the younger trees, but less so on the older trees which change but little from year to year and are probably the largest and most valuable of a group to be rodded. It is the conviction of the writer, however, that the additional protection of both trees and adjacent building often makes the trouble and expense worth while.

PROTECTION OF LIVESTOCK

Livestock is frequently injured or killed by being in contact with or close to an ungrounded wire fence struck by lightning. To avoid this danger, the fence should be effectually grounded at intervals of about 150 feet, more or less, according to the conductivity or

effectiveness of the several grounds. A serviceable ground connection may be had by driving a piece of ¾-inch galvanized-iron pipe about 5 feet deep into the earth alongside the wooden fence post, the upper end about as high as the post, and attaching the fence wires securely to this pipe. (Fig. 19, A.) The pipe may be fastened to the post with plumbers' clips pressing the pipe into secure contact with the fence wire. Another way of grounding a wire fence is illustrated in Figure 19, B, employing a post made of steel angle 1¼ by 1¼ by ⅛ inch in section. Such posts are available on the market in 8-foot lengths, and can be driven readily into the earth. A fence would be reasonably well grounded if these metal posts were substituted for the wooden posts at intervals, and of course an all-metal fence would not ordinarily require separate grounding, especially if some of the posts are extra long and extend well into the earth.

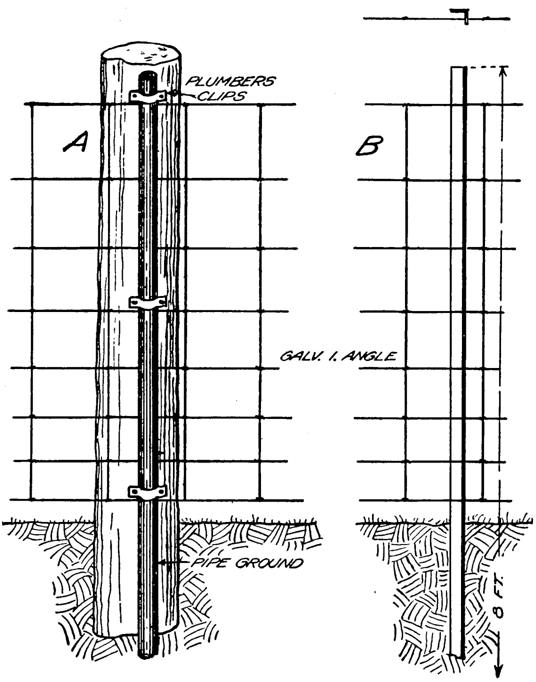

FIG. 19.—Grounding of wire fencing. A, fencing with wooden posts. B, posts of galvanized-iron angle

In addition to the grounding of the fence at intervals that should correspond to the standard lengths in which the wire fencing is furnished; that is, 20, 30, or 40 rods, gaps of several feet should be left in the wire fencing to prevent a lightning discharge from traveling any considerable distance along the fencing. These gaps should be filled in with wooden fencing (a nonconductor of electricity) in a substantial and durable manner.

Occasionally it will be necessary to rod isolated or small groups of shade trees under which stock congregate. The general methods of rodding trees are covered on page 22. It would be advisable, however, to form the ground connections by extending the down conductors into the earth, not vertically, but outward at some considerable angle, say 30°. The down conductor must be protected from injury by the stock by building a stout fence, or providing some other suitable barrier about the foot of the trees. Where there is a small group of trees, only a few of the tallest require rodding. If a grove of trees is available for the stock, it would be advisable to remove isolated trees in the pasture or prevent the animals from using them. No rodding is required for the last-mentioned conditions.

SPECIFICATIONS FOR INSTALLATION OF EQUIPMENT

Three sets of specifications for the installation of different types of equipment are given below. These specifications conform to the principles set forth in the preceding text and in the "Rules for Protecting Telephone and Radio Circuits from Lightning," as given in the National Electrical Code, 1925 Edition (pages 30 to 32, inclusive). They are, of course, general in character and form only a basis or outline to which may be added such further details as are necessary to care for the particular work in hand.

COPPER-CABLE CONDUCTOR

CONDUCTOR

Cable of commercially pure copper weighing approximately 4 ounces per foot will be used, the size of any individual wire in the cable to be not less than No. 17 B. & S. gauge (0.045 inches diameter). The cable will be coursed as directly as possible over the building, with no sharp bends or loops, and in such a manner as to connect each air terminal to all the rest. End-to-end joints of the conductor will be avoided, but if necessary the strands at the cut ends will be interwoven for a distance of 5 or 6 inches and carefully soldered, or solderless connectors of approved type used. Branch conductors from the main cable will be wrapped and soldered, the branch cable meeting the main cable in an arc of at least 2 feet radius. (Fig. 4.)

CABLE FASTENERS

Use gun-metal or heavily galvanized malleable-iron screw fasteners. (Fig. 2, C.) Space the fasteners not more than 4 feet apart, and screw directly into wooden walls and roofs. Lead expansion shields will be used for masonry.

Holes through the roof will be made water-tight by means of elastic roof cement.

No insulators will be used.

AIR TERMINALS

Details of the location of the air terminals are shown in the sketches accompanying these specifications. Tube elevation rods will be employed with an inverted **Y** connection to the main conductor, the walls of the tubing to be not less than No. 20 gauge (0.032 inch) in thickness.

Solid, copper-bayonet air terminal points without plating (Fig. 6, E) will be used.

Air terminals will be 3 feet high above ridges, gables, and flat roofs, and 12 inches above the tops of chimneys, peaks, and pointed parts of the building.

Furnish and install galvanized-iron tripod supports for air terminals, fastening the same to the roof with sheradized-iron screws, through bolts, or expansion screws, as the case requires. When through bolts are used, provide a lock nut or upset the end of the bolt to prevent loss of nut.

GROUND CONNECTIONS

The location of the grounds and down conductors shall conform to the sketches accompanying these specifications.

Provide one outside ground connection to the water piping (if available) where the pipe enters the building. (Fig. 11.)

The additional grounds will be made by drilling the earth to permanent moisture (8 to 10 feet), and inserting the lower end of the down conductor in the hole formed.

At places designated protect the down conductor against injury by stock or otherwise by surrounding it with a 10-foot length of 1-inch galvanized-iron pipe securely fastened to the building, the lower end terminating about 18 inches below ground level. The upper end of the pipe will be electrically connected to the conductor. (Fig. 20.)

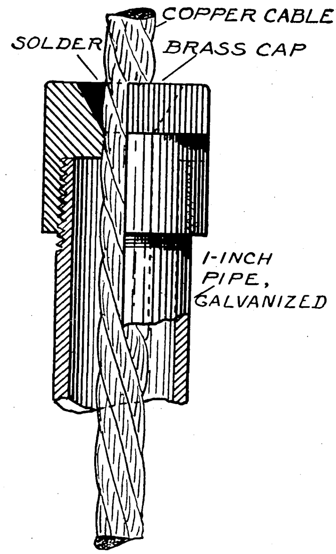

FIG. 20.—Method of electrically connecting down conductor to pipe used to protect the conductor against injury by passing vehicles, stock, etc. Conductors are also protected by a boxing of wood. The protection should extend to a height of 8 to 10 feet from the ground

INTERCONNECTION AND GROUNDING OF METAL WORK OF BUILDING

Cross connect the gutters and down spouts to the lightning conductors, using No. 6 B. & S. gauge copper wire with soldered joints or suitable clamps. Connect the gutters at each end and the down spouts at their lower ends, soldering the gutters to the down spouts.

Pipes and other metal work within the building, extending for a considerable distance parallel to the lightning conductors on the roof or side of building, will be cross connected to the nearest conductor at one end, and grounded within the building or connected to a down conductor on the exterior, provided the distance between the interior metal work and conductor is 6 feet or less. Use No. 6 copper wire and solder or clamp the joints. Small masses of metal in the barns will be grounded to prevent sparking from induction; those in the house do not require grounding or cross connecting.

GALVANIZED-STEEL CONDUCTOR

CONDUCTOR

Galvanized-steel star-section rod with copper couplings will be used, the rod three-fourths inch in diameter. The conductor will be run as directly as possible on the building with no sharp bends or loops, and in such manner as to connect each air terminal to all the rest. Eight-foot sections of rod will be used, and end-to-end joints carefully screwed together. Where branches with the main conductor occur, Y connectors will be used so that bends of at least 2 feet radius may be formed with the laterals.

FASTENERS FOR CONDUCTORS

Use galvanized, malleable-iron screw fasteners. (Fig. 2, C.) Space the fasteners not more than 4 feet apart, and screw directly

into wooden walls and roofs. Lead expansion shields will be used for masonry and concrete walls.

Holes through the roof made by the fasteners will be rendered water-tight by means of elastic roof cement.

No insulators will be used.

AIR TERMINALS

Details of the location of the air terminals are shown in the sketches accompanying these specifications. Star-section elevation rods will be employed with an inverted **Y** connection to the main conductor, the diameter of the elevation rod to be the same as the rod elsewhere used.

Solid, copper-bayonet air terminal points without plating, screwed to the upper end of the elevation rod, will be used. (Fig. 5, A.)

Air terminals will be 3 feet high above ridges, gables, and flat roofs, and 12 inches above the tops of chimneys, peaks, and pointed parts of the building.

Furnish and install galvanized-iron tripod supports for the air terminals, fastening the same to the roof with sheradized-iron screws, bolts, or expansion screws, as the case required. When bolts are used, provide a lock nut or upset the end of the bolt to prevent loss of nut.

GROUND CONNECTIONS

The location of the grounds and down conductors will conform to the sketches accompanying these specifications.

If available, provide one outside connection to the water piping where it enters the building. (Fig. 11.)

The additional grounds will be made by drilling the earth to permanent moisture (8 to 10 feet) and inserting or driving the lower end of the down conductor into the hole formed.

INTERCONNECTION AND GROUNDING OF METAL WORK OF BUILDINGS

Following specifications for "Copper-cable conductor", except that No. 6 galvanized-iron telegraph wire, Birmingham wire gauge, and galvanized-iron fittings and screws will be used instead of copper.

INEXPENSIVE EQUIPMENT: IRON PIPE CONDUCTOR AND FITTINGS

CONDUCTOR [1]

Use ½-inch galvanized, standard-weight pipe for the conductor. The conductor will be run as directly as possible on the building, and in such a manner as to connect each air terminal to all the rest, avoiding sharp bends or loops. Where the conductor passes over the edge of the roof it will be bent into a curve with large radius. Branches from the main conductor at the ends of the roof will be made with **Y**-bend fittings, the branch pipes bent into arcs of large

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[1] Standard pipe and fittings can be readily purchased locally in almost any portion of the United States, or in any event ordered direct from supply houses located in the larger cities. Pipe is readily bent by what is called a hickey. A simple device of this kind can be made with a 1¼-inch malleable-iron tee and piece of 1¼-inch pipe about 30 inches long, screwed to the side outlet to form a handle, as indicated in figure 21.

radius. Intermediate branches with the principal conductor will be made with crosses or tees.

The conductor pipe will be screwed together with galvanized malleable-iron couplings.

CONDUCTOR FASTENINGS

Galvanized-iron pipe straps will be used for fastening the pipe to the building, attaching with iron screws and employing expansion shields for brick, tile, concrete, or stone walls.

Screw holes through the roof will be made watertight by means of elastic roof cement.

AIR TERMINALS

The location of the air terminals is shown in the sketches accompanying these specifications. One-half inch galvanized-iron pipe will be used for the elevation rods, the attachment to the main conductor being made with ½-inch drop tees mounted on substantial wooden blocks attached securely to the roof. (Fig. 5, B.)

The points will be made of iron rod about 6 inches long (Fig. 6, H), and attached to the elevation rods by ⅜ by ½ inch reducing couplings.

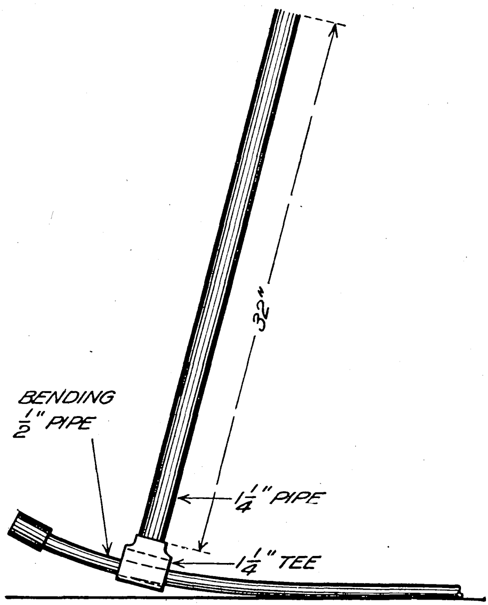

FIG. 21.—Pipe bender or hickey

Air terminals will be 2 feet high above ridges, gables, and flat roofs and 12 inches above the tops of chimneys, peaks, and pointed parts of the building.

GROUND CONNECTIONS

The down conductors will be grounded to 10-foot lengths of 1-inch galvanized pipe, extra heavy if readily obtainable, driven into the earth until their upper ends are about 4 inches above the surface. (In some soils it may be necessary to first drill a hole to receive the pipe.) Connect to the down conductor with a 1 by ½ inch reducing coupling, a short ½-inch nipple, and a ½-inch coupling. (Fig. 16.)

INTERCONNECTION AND GROUNDING OF METAL WORK OF BUILDINGS

Follow specifications for "Copper-cable conductor," except that No. 6 galvanized-iron telegraph wire, Birmingham wire gauge, and iron fittings and screws, galvanized if practicable, will be used instead of copper.

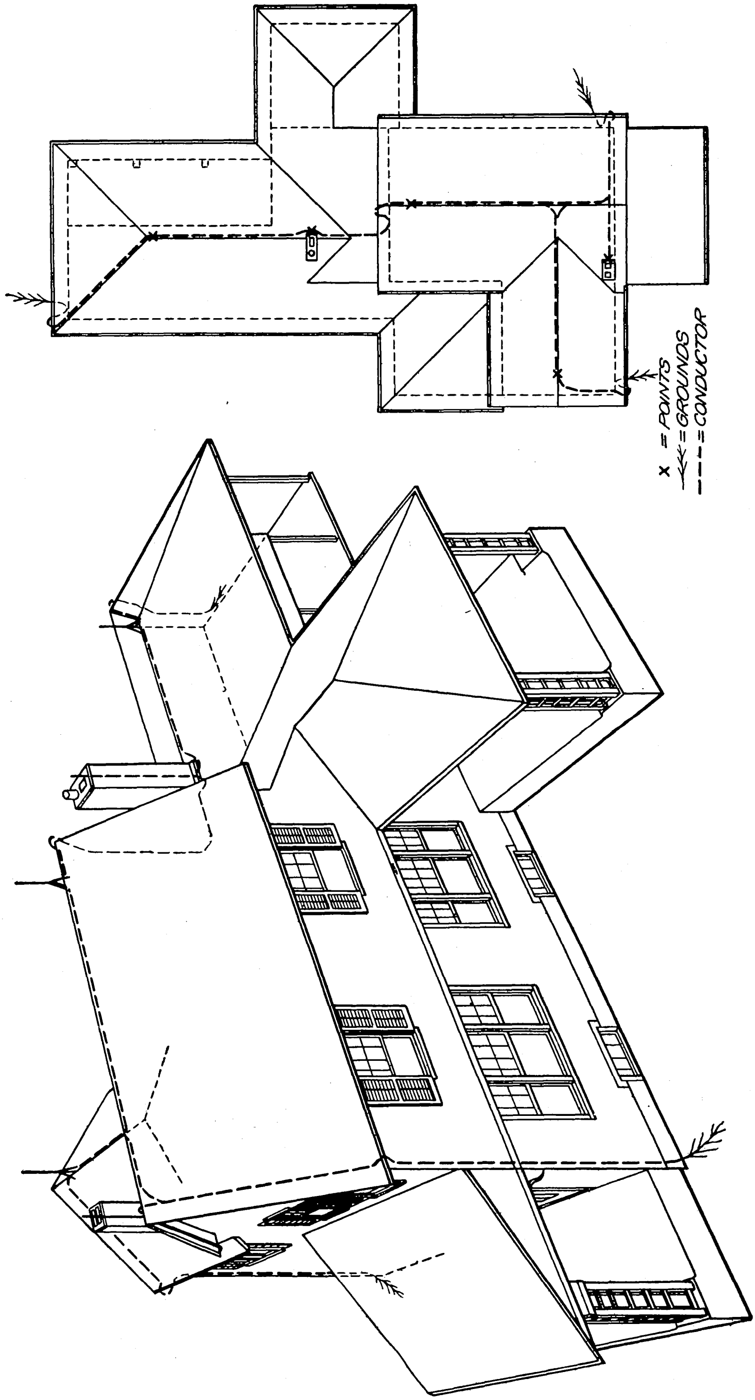

FIG. 22.—Method of installing lightning conductors to protect a farm house from lightning

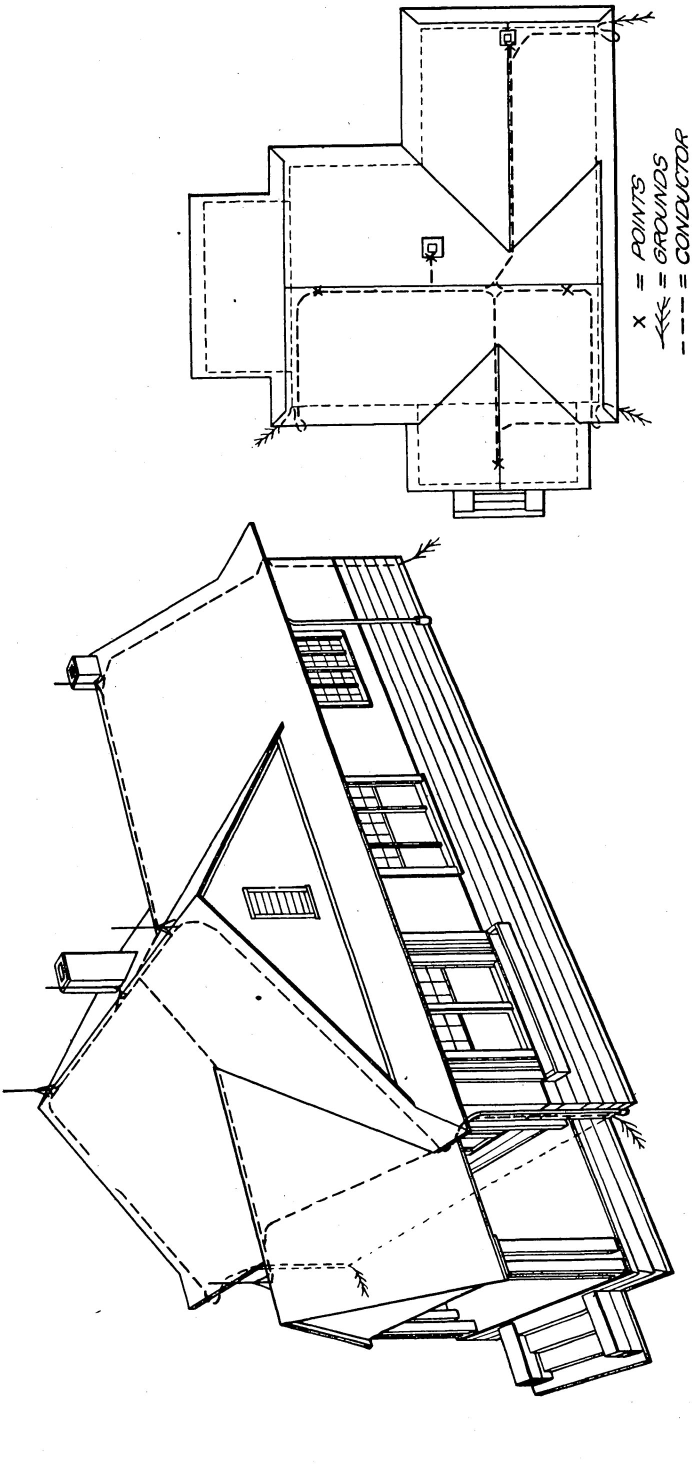

Fig. 23.—Method of installing lightning conductors to protect a farm house from lightning

PROTECTION FROM CORROSION

All parts of the iron which are ungalvanized, or from which the galvanizing has been removed during the installation, will be painted with red lead or metallic to prevent corrosion. (For the sake of appearance a top coat of aluminum paint may be added to the red lead.)

In formation or assistance along lines not covered in this publication, or to explain points not fully understood, will receive careful consideration by correspondence, or the writer referred to the proper authorities. Letters should be addressed to the Weather Bureau, United States Department of Agriculture.

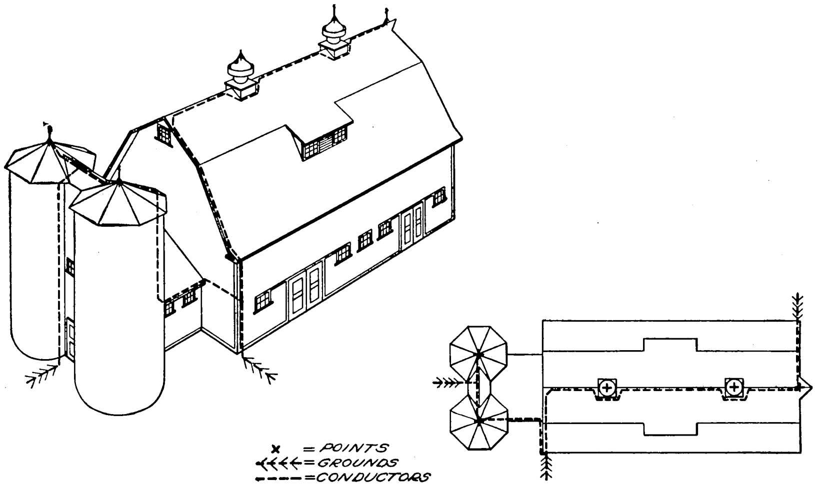

FIG. 24.—Method of installing lightning conductors to protect a small general barn

SPECIAL PROBLEMS IN PROTECTING AGAINST LIGHTNING

RULES FOR PROTECTING TELEPHONE AND RADIO CIRCUITS FROM LIGHTING, AS GIVEN IN THE NATIONAL ELECTRICAL CODE, 1925 EDITION

ARTICLE 37, RADIO EQUIPMENT

3702. For receiving stations only.—(*a*) Antenna and counterpoise outside buildings shall be kept well away from all electric light or power wires of any circuit of more than 600 volts, and from railway, trolley, or feeder wires, so as to avoid the possibility of contact between the antenna or counterpoise and such wires under accidental conditions.

(*h*) Each lead-in conductor shall be provided with an approved protective device (lightning arrester) which will operate at a voltage of 500 volts or less, properly connected and located either inside the building at some point between the entrance and the set which is convenient to a ground, or outside the building as near as practicable to the point of entrance. The protector shall not be placed in the immediate vicinity of easily ignitable stuff, or where exposed to inflammable gases or dust or flyings of combustible materials.

(*i*) If an antenna grounding switch is employed, it shall, in its closed position form a shunt around the protective device. Such a switch shall not be used as a substitute for the protective device.

It is recommended that the antenna grounding switch be employed, and that in addition a switch rated at not less than 30 amperes, 250 volts, be located between the lead-in conductor and the receiver set.

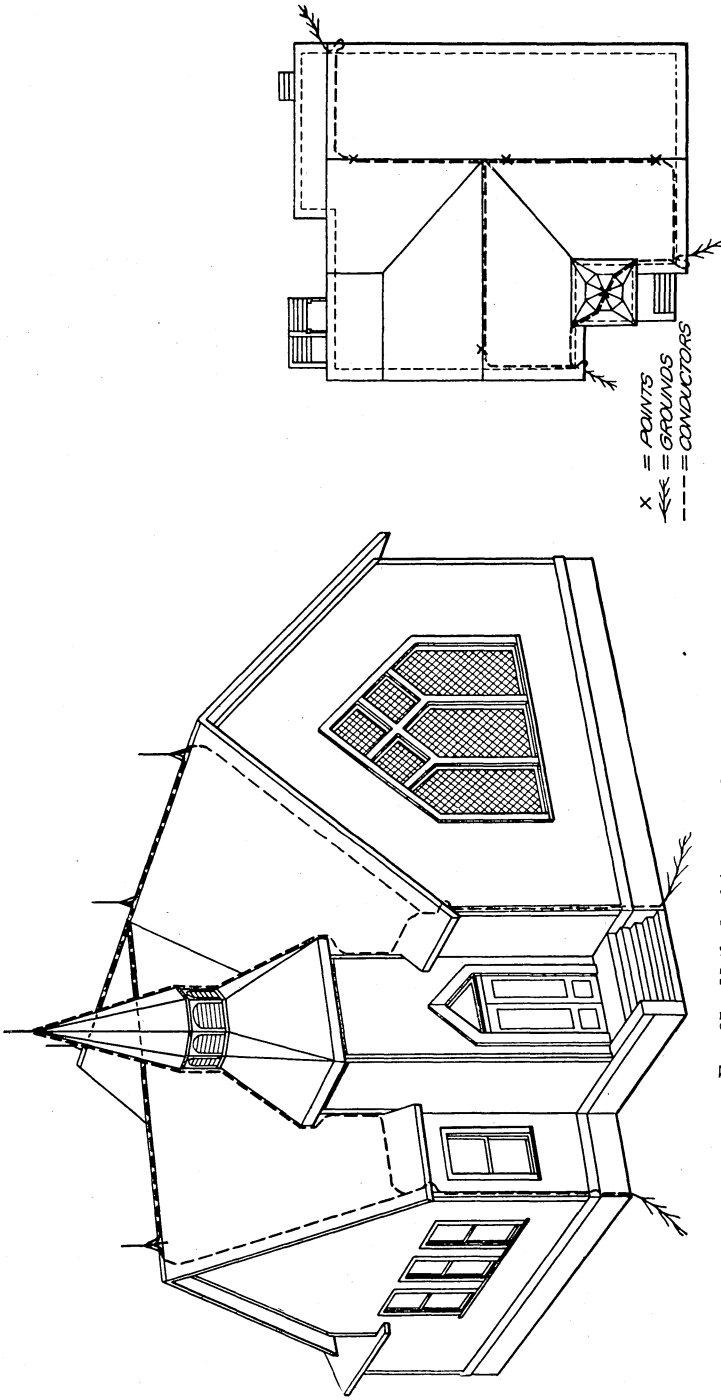

Fig. 25.—Method of installing lighting conductors to protect a church building

(*j*) If fuses are used, they shall not be placed in the circuit from the antenna through the protective device to ground.

(*k*) The protective grounding conductor may be bare and shall be of copper, bronze, or approved copper-clad steel. The protective grounding conductor shall be not smaller nor have less conductance per unit of length than the lead-in conductor, and in no case shall be smaller than No. 14 if copper nor smaller than No. 17 if of bronze or copper-clad steel. The protective grounding conductor shall be run in as straight a line as possible from the protective device to a good permanent ground. Preference shall be given to water piping. Other permissible grounds are grounded steel frames of buildings or other grounded metal work in the building, and artificial grounds such as driven pipes, rods, plates, cones, etc. Gas piping shall not be used for the ground.

(*l*) The protective grounding conductor shall be guarded where exposed to mechanical injury. An approved ground clamp shall be used where the protective grounding conductor is connected to pipes or piping.

(*m*) The protective grounding conductor may be run either inside or outside the building. The protective grounding conductor and ground, installed as prescribed in the preceding paragraphs *k* and *l*, may be used as the operating ground.

> It is recommended that in this case the operating grounding conductor be connected to the ground terminal of the protective device.
>
> If desired, a separate operating grounding connection and ground may be used, this operating grounding conductor being either bare or provided with an insulated covering.

ARTICLE 60. SIGNAL SYSTEMS

6004. In buildings; where the distribution system consist of aerial wires.—(*a*) An approved protector shall be placed as near as practicable to the point of entrance to the building. The protector shall be mounted on a noncombustible, nonabsorptive insulating base and shall consist of an arrester between each line wire and ground and a fuse in each line wire, the fuses protecting the arrester. The protector terminals shall be plainly marked to indicate "line," "instrument," and "ground."

(*b*) The protector shall not be placed in the immediate vicinity of easily ignitable material or inflammable gases, or dust or flying of combustible material.

Grounding.—(*a*) The ground conductor of the protector shall consist of not less than No. 18 copper, having $\frac{1}{32}$-inch rubber insulation, covered with a substantial braid. Where necessary, it shall be guarded from mechanical injury.

(*b*) The ground conductor shall be run in as straight a line as possible to a permanent and effective ground. Where connection is made to a gas pipe, attachment shall be made between the meter and the street main. In every case the attachment shall be made as close to the earth as practicable.

> A suitable ground may be obtained by connection to either a water pipe or a gas pipe, preferably to the former. A ground rod or pipe driven into permanently damp earth is acceptable, in the absence of a piping system.

(*c*) The ground conductor shall be attached to the pipe by means of an approved bolted clamp to which the conductor is soldered or otherwise connected in an approved manner, or the pipe shall be tinned with rosin flux solder after which the conductor shall be wrapped around the pipe and thoroughly soldered to it.

(*d*) Steam or hot-water pipes shall not be employed as a ground for protectors.

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